THE FEMALE CHROMOSOME GROUPS IN SYROMASTES AND PYRROCHORIS.

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The conditions seen in *Syromastes marginatus* L. are of interest on account of the light that they throw on those observed by Morgan in Phylloxera, as reported by him at the December meeting of the American Society of Zoölogists, and recently published in the issue of *Science* for Feb. 5, 1909. In both forms the " accessory " chromosome is not a single but a double body, and the female chromosome-groups contain two more chromosomes than the male.

A reëxamination of the spermatogenesis of *Syromastes*[1] led to a confirmation of Gross's result that the spermatogonial number is even (22), and that the " accessory " chromosome is formed by the union of two chromosomes that are separate in the spermatogonia. This double element divides equationally in the first spermatocyte-division but passes undivided to one pole in the second, so that half the spermatozoa receive two more chromosomes (12) than the other half (10). This led me to the inference that the female somatic groups should have two more chromosomes than the male—*i. e.*, 24 instead of 22, as had been described by Gross. I had at that time no female material, but through the kindness of Professor Boveri have since obtained an abundant supply of the ovaries. Examination of this material demonstrated the correctness of my earlier inference. A considerable number of ovaries have been sectioned, many of which contain numerous and very fine division-figures, showing the chromosomes with great clearness. Whenever a good view of the equatorial plate can be obtained, 24 chromosomes are unmistakably seen to be present, as is clearly shown in photographs. Two figures (Fig. 1, *c, d*) are appended, both of which were drawn upon enlarged photographs by the method described in my fourth " Study." *Syromastes* is an exceptionally favorable form

[1] " Studies on Chromosomes, IV., " *Journ. Exp. Zool.*, VI., 1, 1909.

for study, and the diagrammatic clearness with which the chromosomes appear in many of the sections precludes, I think, the possibility of error in respect to the number.

In my description of the male groups I emphasized the fact that the two components of the "accessory" are of slightly un-

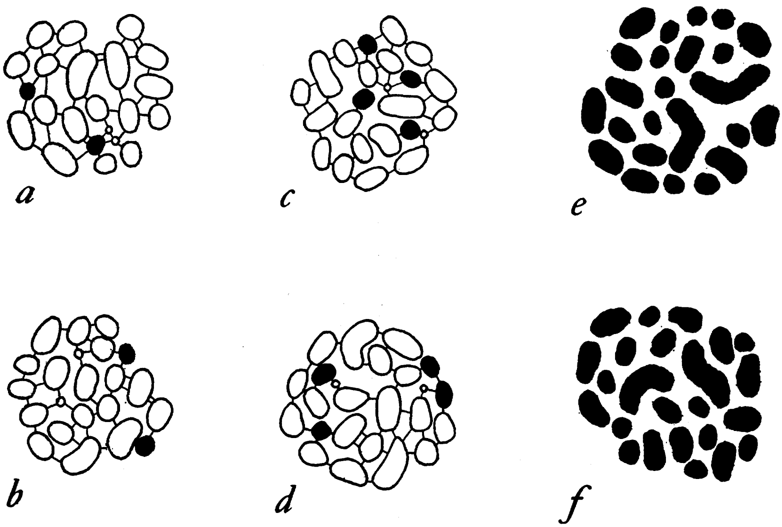

FIG. 1. *a, b, Syromastes marginatus* L., spermatogonial chromosome-groups; *c, d,* ovarian groups of the same; *e, f, Pyrrochoris apterus* L., ovarian chromosome-groups.

equal size (as is shown in the photographs accompanying the paper), and that they are recognizable in the spermatogonial groups as two separate chromosomes which are the second and third smallest of all the chromosomes. In the female groups each of these chromosomes is represented by a corresponding pair (black in the figures). In most of the ovarian groups the smaller two are readily recognizable, and in some cases, though not always, this is also true of the larger pair. The numerical and size-relations are such as to show that after maturation the egg must contain one member of each of these pairs. Though nothing is directly known of the maturation-process in the female, it may be inferred with probability that in synapsis the two larger and the two smaller of these pairs unite to form two corresponding bivalents, which may be designated as *aa* and *bb* (*II* and *ii*,

in the terminology of my former paper). By the subsequent disjunction of each of these pairs the mature egg receives *a* and *b* in addition to 10 other chromosomes. Fertilization of the egg by a spermatozoön containing the "accessory" $(a + b)$ will therefore give the characteristic female group $(a, b, a, b + 20)$, while fertilization by one that lacks $a + b$ will give the male group $(a, b + 20)$. For the sake of comparison two of the spermatogonial groups are reproduced in Fig. 1, *a, b*. In the figures of both sexes the chromosomes identified as *a* and *b* are made black. The essential relations in both sexes are shown in the diagram,

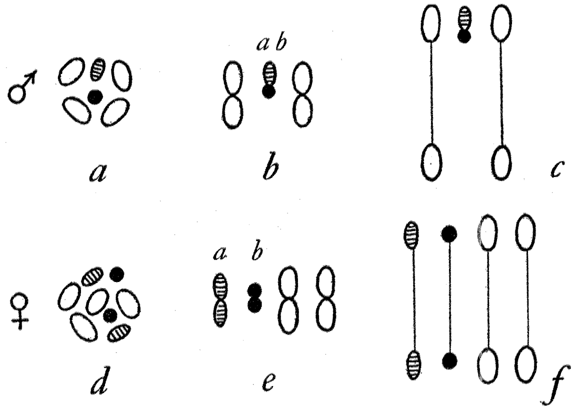

FIG. 2. Diagrams of maturation in *Syromastes*. *a*, spermatogonial chromosomes (actual number 22); *b, c*, spermatocyte-division; *d*, ovarian chromosomes (actual number 24); *e, f*, maturation division (inferred).

Fig. 2, in which *a* is cross-barred, *b* black, and the other chromosomes (of which only four are represented) are in outline.

It is evident that, except for the different total number of chromosomes in the two species, these phenomena are essentially similar to those seen in *Phylloxera fallax*, which likewise has two "accessories" and two more chromosomes in the female somatic groups (12) than in the male (10). In *Phylloxera caryæcaulis* the two "accessories" are of unequal size, as in *Syromastes*, but the phenomena are complicated by the fact that these two chromosomes are often united in the somatic groups of the male, and are apparently always thus united in those of the female. In the male they are always united at the time of the spermatocyte-

divisions to form the "accessory," which is in reality double, like that of *Syromastes,* and sometimes separates into its two components as it moves to the pole. Morgan therefore concludes that the true numbers of the chromosomes in the two sexes of this species are eight and six respectively, though the female seems to show but six and the male either five or six (according as the two "accessories" are united or separate).

The point to which I would call attention is the similarity between *Phylloxera caryæcaulis* and *Syromastes* in respect to the mode of synapsis. In the spermatogenesis of both forms the two unequal "accessories" unite in synapsis (if the process can properly be so called) to form the bivalent *ab,* consisting of two unequal components, which passes into the female-producing spermatozoa. In the maturation of the male-producing egg of *Phylloxera,* however (and apparently the same must be true of the sexual eggs), a different process takes place, the two larger and the two smaller components uniting to form the bivalents *aa* and *bb,* again exactly as there is reason to conclude in the case of the egg of *Syromastes.* In *Phylloxera,* as Morgan points out, this involves a redistribution of the four chromosomes, since in the somatic groups they are united to form *ab* and *ab,* but recombine at the maturation period to form *aa* and *bb.* This remarkable redistribution, I think, loses much of its anomalous character on comparison with the facts in *Syromastes,* where *a* and *b* are always separate in the somatic groups.

These facts, together with those determined by Payne in *Fitchia* and other forms (now in press in this journal) and my own earlier ones on *Thyanta,*[1] which shows essentially the same conditions as in *Fitchia,* lead me to a somewhat different interpretation of the "accessory" chromosome in *Syromastes* from that given in my fourth "Study." In that paper I adopted the conclusion that the two components of the bivalent "accessory" were identical respectively with the large and small "idiochromosomes" of such forms as *Metapodius* or *Lygæus.* I did not then see that all the facts are equally consistent with the view that these two components, *taken together,* represent the single odd

[1] Reported at the meeting of the American Society of Zoölogists in December, 1906, but still unpublished.

chromosome of *Anasa, Protenor* and other similar forms, and that the small idiochromosome has disappeared. Payne discovered that in the reduvioids, where a single small idiochromosome or " Y-element "[2] is always present, the large idiochromosome is in some species a single chromosome (*Diplocodus*), in others is represented by two (*Fitchia, Conorhinus*) or three chromosomes (*Prionidus*), and in the galgulid genus *Gelastocoris* (*Galgulus*) by four chromosomes, which behave in maturation as a single unit (X-element) that is obviously comparable to a single large idiochromosome in its relation to sex-production. Payne concludes, with great probability, that the double or multiple X-element in these forms has arisen by the separation of an originally single large idiochromosome (such as still exists in related species) into two or more components. In *Conorhinus,* where the X-element is double, the two components are unequal in size, and by the disappearance of the Y-element a condition would arise closely similar to that seen in *Syromastes.*

Whether such has been the actual mode or origin in *Syromastes* or not, it seems probable that here too the double " accessory " was originally a single chromosome that has separated into two parts, which still act as a unit in the maturation divisions and retain the same relation to sex-production as the original one. *Phylloxera caryæcaulis* may plausibly be regarded as in process of transition from the condition in which a single " accessory " chromosome is present (as appears to be the case in the aphids) to one in which it has separated into two parts, as in *Syromastes.*

I will add a brief account of the female groups in *Pyrrochoris apterus* L., material for which has also been obtained through Professor Boveri. A reëxamination of the male groups (Wilson, Study IV.) showed the spermatogonial number to be 23, including a single unpaired idiochromosome (" accessory " chromosome) which is at once recognizable from the fact that it is nearly twice the size of any of the other chromosomes. This passes into half the spermatozoa, which receive 12 chromosomes, while the others receive but 11, as was originally described by Henking. The

[2] In a recent general discussion I have used the terms " X-element " and " Y-element " to designate respectively the large and small idiochromosomes, or their homologues, whether they consist of a single chromosome or of more than one. See *Science,* XXIX., 732, January 8, 1909.

female groups clearly show 24 chromosomes, of which two are of the same relative size as the unpaired one of the male. Two of the ovarian groups, typical of many others observed, are shown in Fig. 1, *e, f*. These facts show that *Pyrrochoris* conforms to the ordinary type in which the male has an odd chromosome, as in *Anasa, Protenor, Alydus, Largus* and many others.

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